JAPAN PATENT OFFICE

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: March 27, 2001

Application Number: Japanese Patent Application No. 2001-090711

[ST.10/C]: [JP2001-090711]

Applicant(s): RICOH COMPANY, LTD.

May 14, 2002

Commissioner,
Japan Patent Office Kouzo Oikawa (Seal)

Certificate No.2002-3035050

I, Tadahiko Itoh, a Patent Attorney of Tokyo, Japan having my office at 32nd Floor, Yebisu Garden Place Tower, 20-3 Ebisu 4-Chome, Shibuya-Ku, Tokyo 150-6032, Japan do solemnly and sincerely declare that I am the translator of the attached English language translation and certify that the attached English language translation is a correct, true and faithful translation of Japanese Patent Application No. 2001-090711 to the best of my knowledge and belief.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Tadahiko ITOH
Patent Attorney
ITOH International Patent Office
32nd Floor,
Yebisu Garden Place Tower,
20-3 Ebisu 4-Chome, Shibuya-Ku,
Tokyo 150-6032, Japan

Partial Translation

of

Japanese Patent Application 2001-090711

Filed on

March 27, 2001

[CLAIM 6] A semiconductor distributed Bragg reflector as claimed in claim 4, wherein a main layer and a heterospike relaxation layer constituting said semiconductor distributed Bragg reflector having a carrier density in the range from 5 x 10^{17}[cm^{-3}] to 2 x 10^{18}[cm^{-3}], said heterospike relaxation layer having a thickness in the range from 5 [nm] to 40 [nm], an average change rate of Al composition in said region II being in the range from 0.02 [nm^{-1}] to 0.15 [nm^{-1}].

[0015]

(6) The invention of claim 6 has a feature in that a main layer and a heterospike relaxation layer constituting said semiconductor distributed Bragg reflector of claim 4 have a carrier density in the range from 5 x 10^{17}[cm^{-3}] to 2 x 10^{18}[cm^{-3}], the heterospike relaxation layer has a thickness in the range from 5 [nm] to 40 [nm], an average change rate of Al composition in the region II is in the range from 0.02 [nm^{-1}] to 0.15 [nm^{-1}]. Here, the Al compositional gradient in the region I is defined as "Al compositional gradient = {variation (0-1) of Al

content in the region I}/dI". By choosing each parameter of the heterospike buffer layer 12 that includes the distributed Bragg reflector to the foregoing range, reduction of resistance is achieved easily and effectively.

[0060]

FIG.13 shows the Al composition gradient that provides minimum of the electric resistance and the corresponding sheet differential resistance for the case of changing the carrier density of the distributed Bragg reflector and the heterospike buffer layer 12 (5×10^{17}[cm^{-3}], 2×10^{18}[cm^{-3}]) and the thickness of the heterospike buffer layer 12 in the structure of FIG.6, together with the percentage of the electric resistance decrease in comparison with the case in which a simple linear compositional gradient is used for the heterospike buffer layer (the structure of FIG.2).

[0061]

In view of increase of electrical resistance with decrease of the carrier density, the value of 5×10^{17} [cm^{-3}] is chosen as the actually allowable lower limit. Further, a value of 2×10^{18} [cm^{-3}] is chosen as the allowable upper limit in view of conspicuous optical absorption particularly in the case of a p-type semiconductor.

[0062]

In the case the thickness of the heterospike buffer layer 12 is increased, a remarkable decrease of resistance is achieved. On the other hand, such a decrease of the thickness of the heterospike buffer layer 12 is not preferable in view of decrease of reflectance of the distributed Bragg reflector. From the viewpoint of reflectance, it is believed that the value of 40 [nm] or less is important for the practical thickness of the heterospike buffer layer.

[0063]

In the case the thickness is too small, the desired resistance decrease is not attained. Thus, it is believed that the value of 5 [nm] or more is important for the thickness of the heterospike buffer layer 12 for realizing sufficient resistance reduction effect.

[0064]

As compared with the case of the simple compositional gradation layer in which the Al content is changed linearly from the small-bandgap layer to the large-bandgap layer constituting the main layers of the distributed Bragg reflector, the foregoing construction can achieve further reduction of the

resistance. Within the foregoing range, the differential sheet resistance is decreased to about 75% (1.2 x 10^{-9} [Ωcm^2] in terms of differential sheet resistance) in the embodiment of claim 3, and thus a significant effect is achieved.

[0065]

Thus, the present embodiment can reduce the resistance further as compared with the case of using the linear compositional gradient in the heterospike buffer layer 12 of the same thickness. In the case of achieving the same resistance value, on the other hand, the present embodiment allows the use of reduced thickness for the necessary heterospike buffer layer 12. Thus, adversary effect on the optical properties such as reflectance is minimized.

Thus, it becomes possible to obtain a distributed Bragg reflector excellent in terms of electric properties and optical properties, by choosing the structure of the distributed Bragg reflector and heterospike buffer layer as set forth in the claims.

[FIG.13]

Heterospike buffer layer thickness	5 x 10^{17}[cm^{-3}] carrier density	2 x 10^{18}[cm^{-3}] carrier density
5 [nm]	0.16[nm^{-1}]/8.4x10^{-6}[Ωcm^2]/83%	0.16/4.5x10^{-8}[Ωcm^2]/90%
40 [nm]	0.02[nm^{-1}]/2.1x10^{-9}[Ωcm^2]/91%	. . .